

Predicting Zoonotic Hemorrhagic Fever Events in Sub-Saharan Africa using NASA Earth Science Data for DoD - Global Emerging Infections Surveillance and Response System

Jorge E. Pinzon, SSAI at NASA/GSFC



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Contributors

Remote Sensing Data

- Jorge Pinzon, Assaf Anyamba & Compton J. Tucker: NASA/Goddard Space Flight Center, Biospheric Sciences Branch, Code 614.4, GIMMS Group, Greenbelt, Maryland.

Field Surveillance & Data Support

- Kenneth J. Linthicum & Seth Britch: Center for Medical, Agricultural & Veterinary Entomology, Agricultural Research Service, United States Department of Agriculture, Gainesville, Florida.
- Emad Mohareb, Naval Medical Research Unit 3 (NAMRU-3), Cairo, Egypt

Armed Forces Health Surveillance Center

- Kevin Russell, Clair Witt: Div GEIS Operations, Silver Spring, MD

World Health Organization

- Pierre Formenty



United States Department Of Agriculture
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Overall Goal: strengthen DoD-GEIS efforts to build a sustainable global capacity for predictive surveillance to promote preparedness in US Forces, the Military Health System and the Global Public Health community.

Specific aims:

- Get a better understanding of eco-climatic/disease linkages and their critical pathways to support surveillance and control activities.
- Refine the early warning models for Rift Valley Fever (RVF), and Marburg/Ebola Hemorrhagic Fever (MHF/EHF) filoviruses in Sub-Saharan Africa with multi-level monthly risk maps.
- Study potential **extension** of models to other regions and diseases.
- Prototype the development and production of an environmental quality data record (NDVI-rainfall-temperature) that ensures **consistency** and **continuity** of data ingest to early warning models and **transferability**.
- Analysis, predictions and models that provide timely and coherent SYNTHESIS of otherwise disparate information

GIMMS

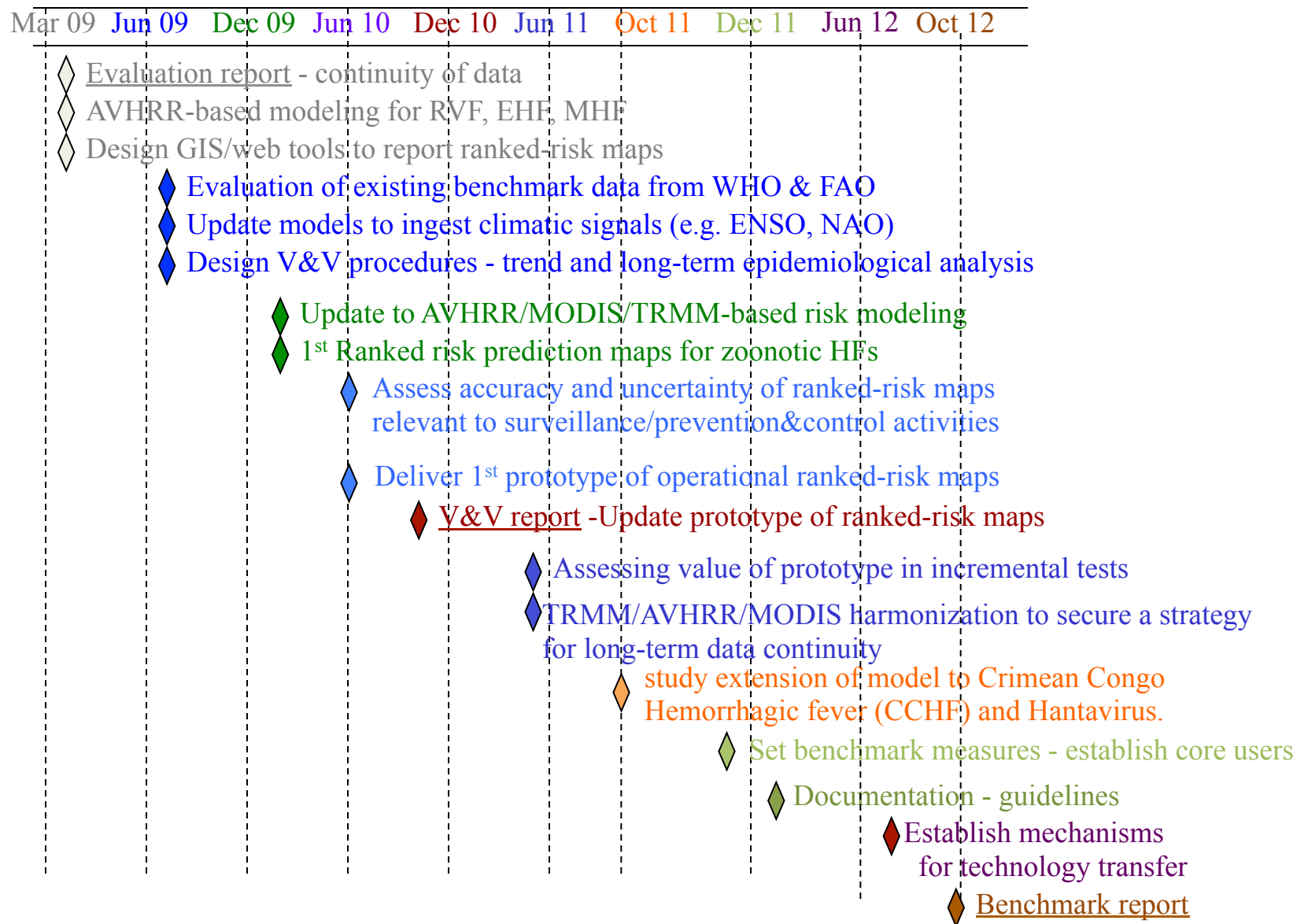
Global Inventory Monitoring and Mapping Studies



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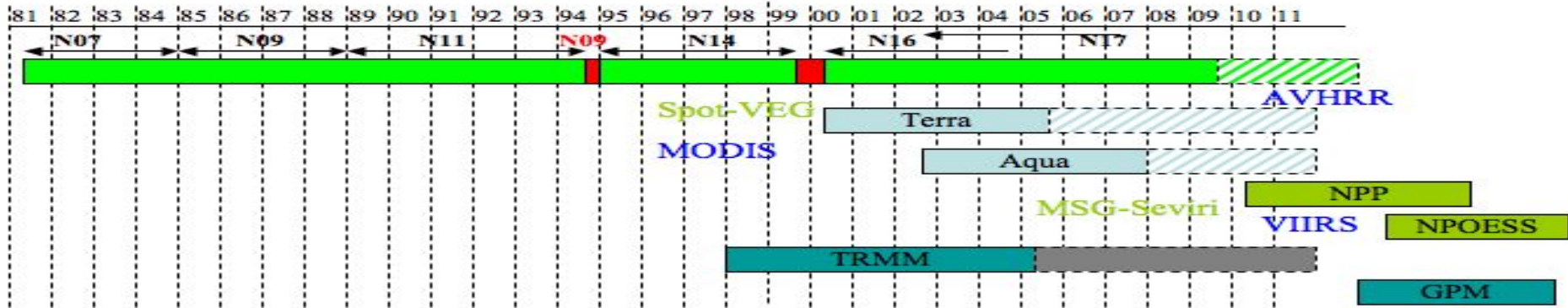


Project milestones



Data harmonization

Securing long-term data continuity



Inputs

Current Sensor/Data

Integrating Intermediate data

Extended long-term monitoring

Global Climate indicators

Multivariate ENSO Index
NAO, PDO

Disease, Vector & Animal Data

Imagery time series

Precipitation (PPTN)
Normalized Difference
Vegetation Index (NDVI)
NDVI / Temperature

Sea Surface Temperature (SST)
Outgoing Longwave Radiation (OLR)
From NOAA(monthly updates)

Latitude&Longitude&Date

TRMM - monthly update
AVHRR - biweekly or as needed
MODIS - monthly

SeaWIFS
MODIS

Hyperion data

GPM / 2013

NPP-VIIRS
2011

GIMMS

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NASA/GIMMS Production System

Extending model

AVHRR
1981 - present

- Geolocation
- Calibration
- Cloud/Shadow Screening
- Atmospheric Correction

Land products

Gridding

AVHRR products

Other Risk Indicators

- Animal surveillance
- Vector habitats
- Human cases

MODIS
2001 - present

- Geolocation
- Calibration
- Cloud/Shadow Screening
- Atmospheric Correction

Land products

Gridding

MODIS products



ENSO + DEM + LandCover
Precipitation: TRMM

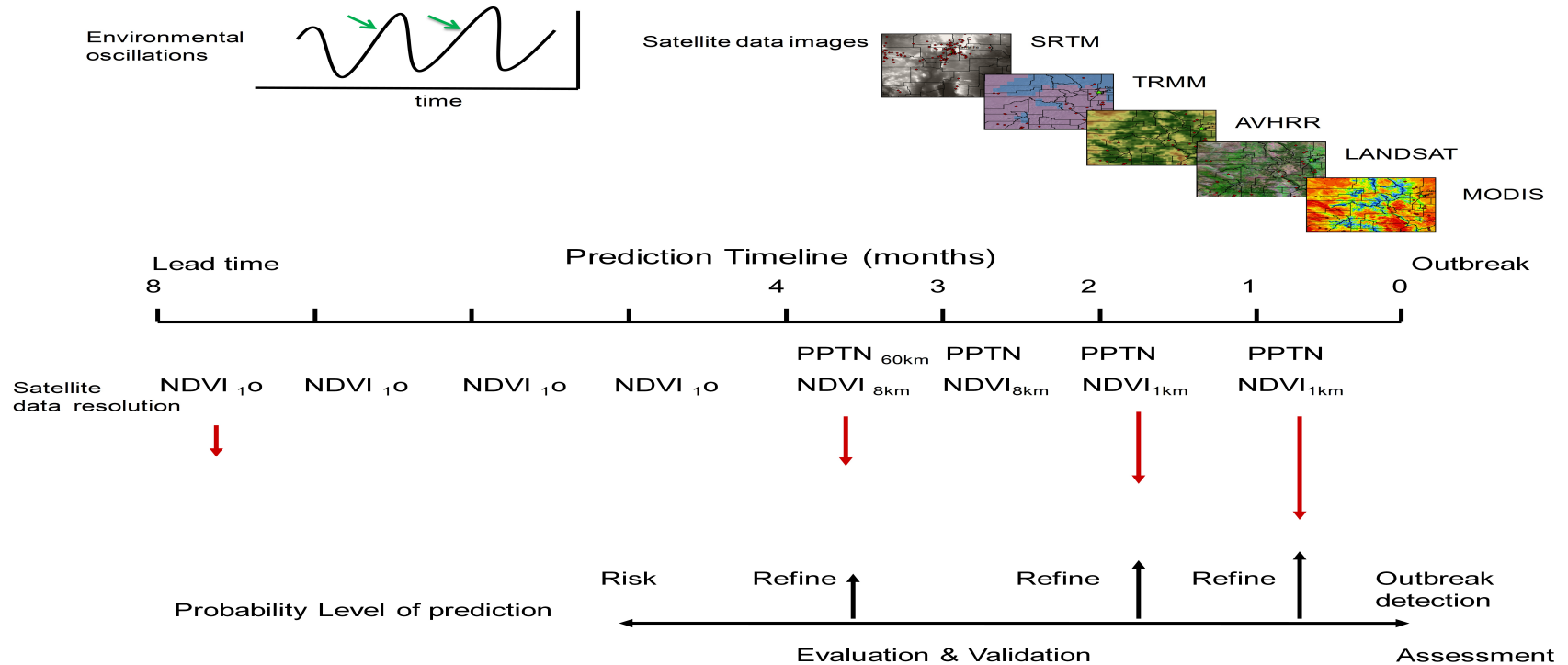
List of potential products:
Surface Reflectance, VI,
Normalized Anomalies,
Spatial&Temporal Ranking
of Risk

Web-based Integration:
Daily, multi-day, monthly
Analysis and dissemination
Benchmark measures
Transfer technology

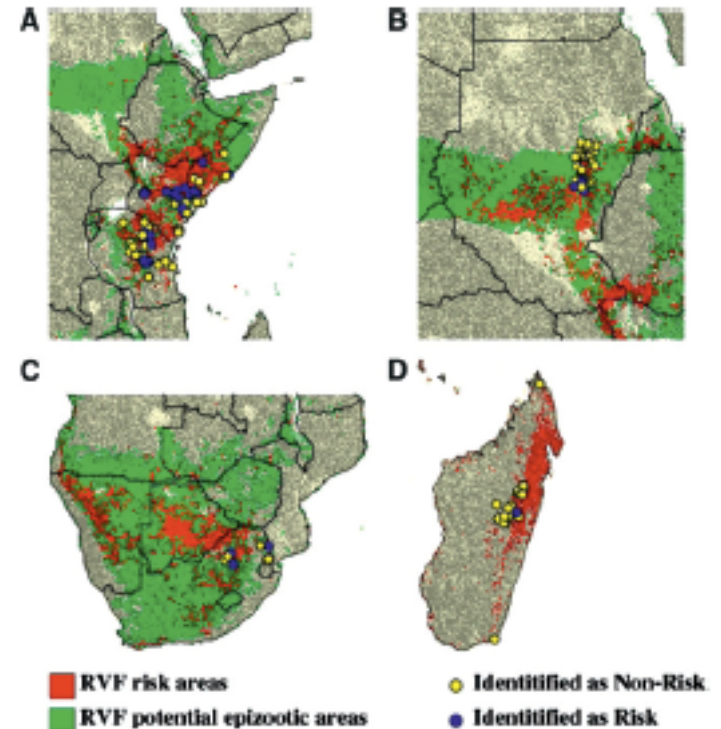
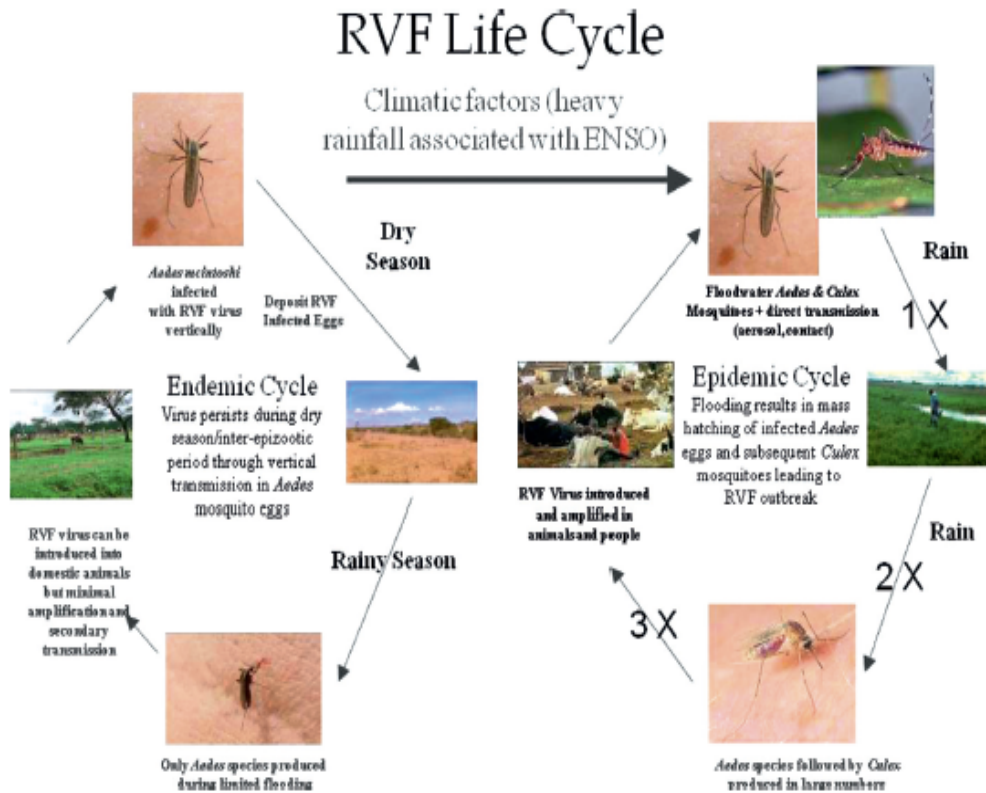
Spatio-temporal modeling: framework prediction

Accuracy, continuity, expansion and transferability

Model Prediction Framework



RVF in other regions



Am. J. Trop. Med. Hyg., 83(Suppl 2), 2010, pp. 43–51

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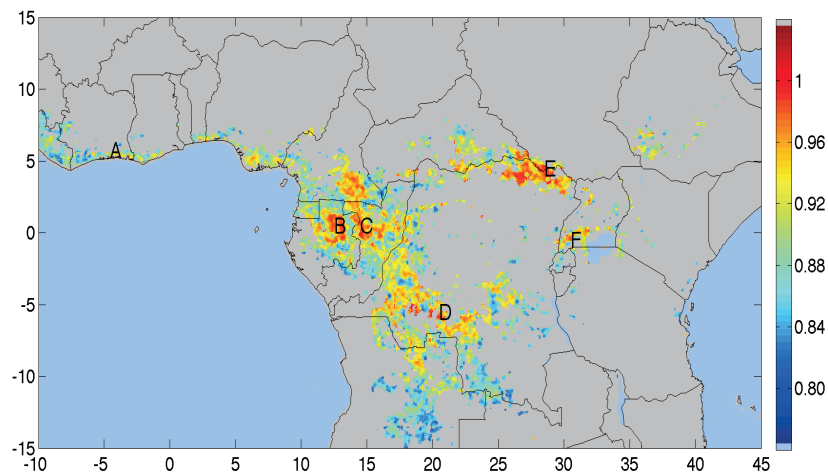
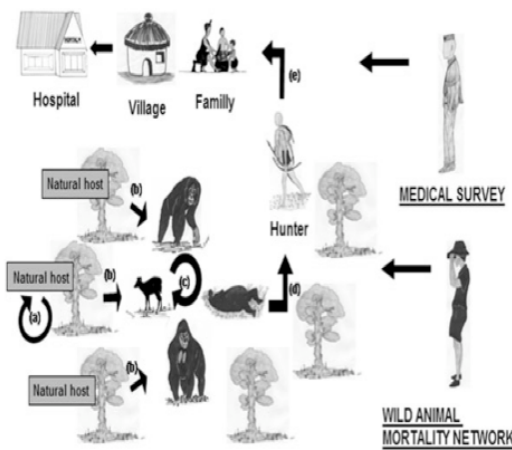
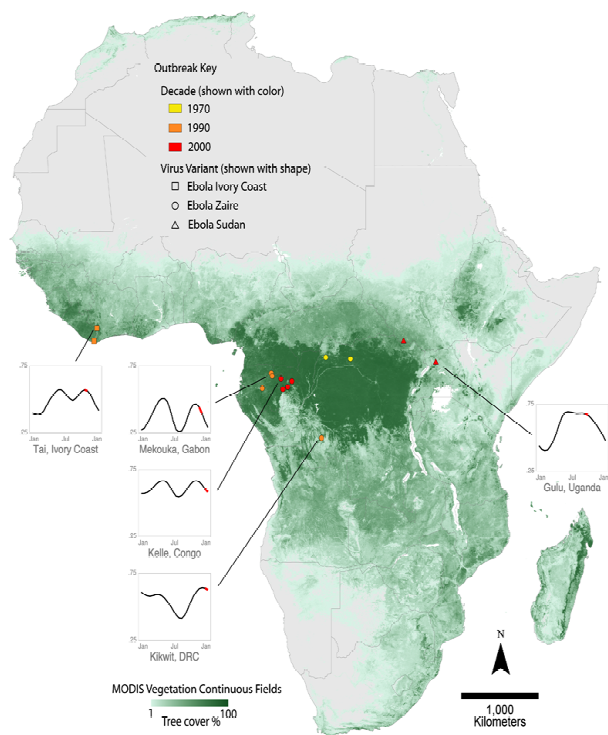
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EHF - Modeling



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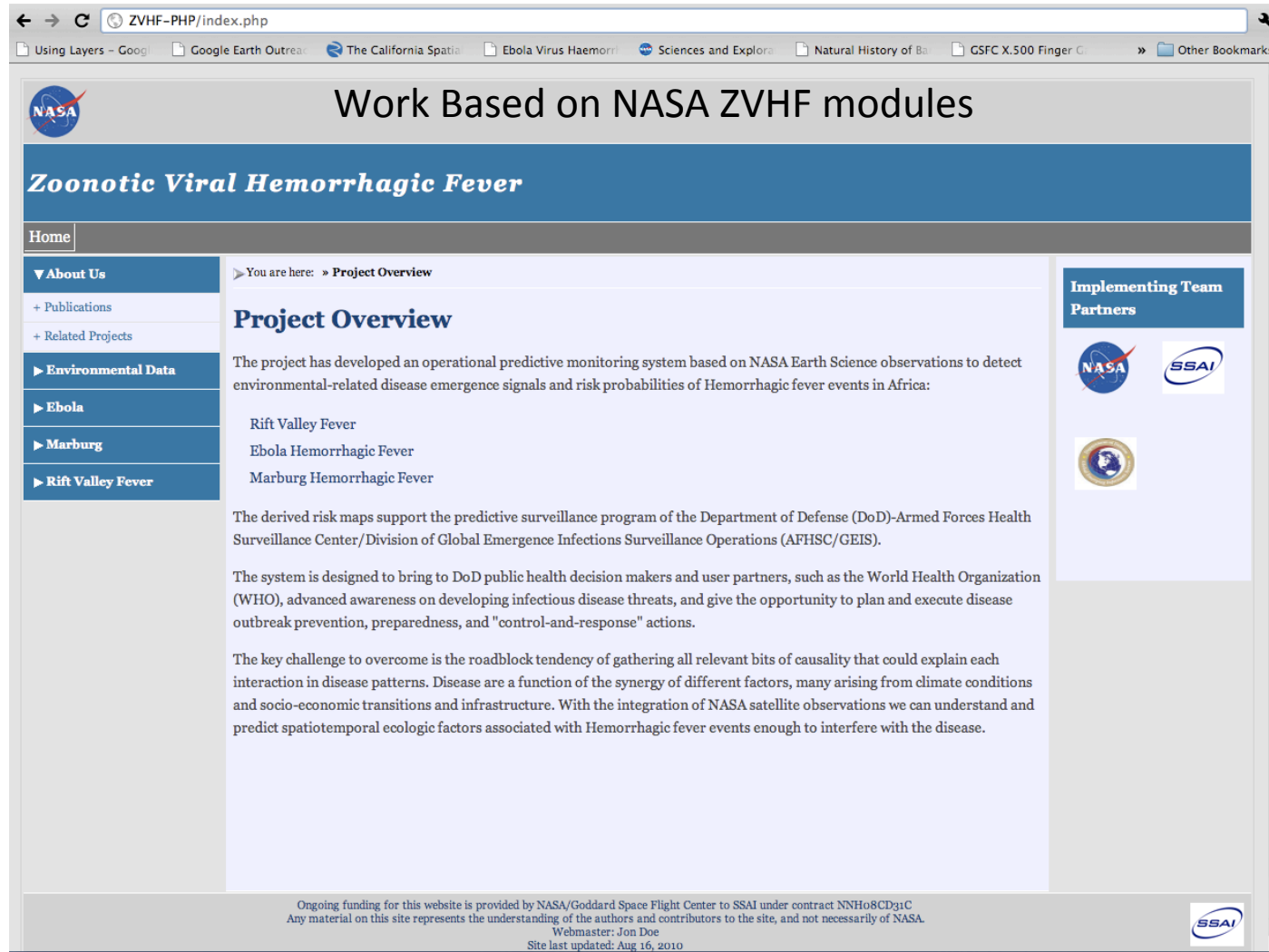
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Technology transfer



← → ↻ ZVHF-PHP/index.php

Using Layers - Google | Google Earth Outbreak | The California Spatial | Ebola Virus Haemorrhagic | Sciences and Exploration | Natural History of Bacteria | GSFC X.500 Finger | Other Bookmarks

Work Based on NASA ZVHF modules

Zoonotic Viral Hemorrhagic Fever

Home

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- + Publications
- + Related Projects

► Environmental Data

► Ebola

► Marburg

► Rift Valley Fever

► You are here: ► Project Overview

Project Overview

The project has developed an operational predictive monitoring system based on NASA Earth Science observations to detect environmental-related disease emergence signals and risk probabilities of Hemorrhagic fever events in Africa:

- Rift Valley Fever
- Ebola Hemorrhagic Fever
- Marburg Hemorrhagic Fever

The derived risk maps support the predictive surveillance program of the Department of Defense (DoD)-Armed Forces Health Surveillance Center/Division of Global Emergence Infections Surveillance Operations (AFHSC/GEIS).

The system is designed to bring to DoD public health decision makers and user partners, such as the World Health Organization (WHO), advanced awareness on developing infectious disease threats, and give the opportunity to plan and execute disease outbreak prevention, preparedness, and "control-and-response" actions.

The key challenge to overcome is the roadblock tendency of gathering all relevant bits of causality that could explain each interaction in disease patterns. Disease are a function of the synergy of different factors, many arising from climate conditions and socio-economic transitions and infrastructure. With the integration of NASA satellite observations we can understand and predict spatiotemporal ecologic factors associated with Hemorrhagic fever events enough to interfere with the disease.

Implementing Team Partners

- NASA
- SSAI

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Site last updated: Aug 16, 2010

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Sep 2011

Communication and transfer of data

RVF

Previous Reports

RVF0907.pdf	11-Dec-2009 18:21 2.4M
RVF0910.pdf	11-Dec-2009 19:58 2.4M
RVF0911.pdf	11-Dec-2009 20:06 2.5M
RVF0912.pdf	17-Mar-2010 15:07 2.4M
RVF1001.pdf	17-Feb-2010 20:02 2.3M
RVF1002.pdf	18-Mar-2010 18:25 2.3M
RVF1003.pdf	15-Apr-2010 11:03 2.6M
RVF1004.pdf	18-May-2010 15:56 2.7M
RVF1005.pdf	15-Jun-2010 19:36 2.7M
RVF1006.pdf	19-Jul-2010 21:21 2.5M
RVF1007.pdf	13-Aug-2010 07:25 2.4M
RVF1008.pdf	21-Sep-2010 10:48 2.4M
RVF1009.pdf	18-Oct-2010 10:46 2.5M
RVF1010.pdf	12-Nov-2010 13:03 2.7M

RVF

current risk map



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Global Inventory Monitoring and Mapping Studies



Responding to expansion of AFHSC-GEIS predictive surveillance program

GEIS Predictive Surveillance: Remote Sensing Component

HOME PROJECT OVERVIEW ABOUT US

Search Parameters

Date: Oct 2010

Submit

Search Results

Current Month: November 2010

Environmental Data

NDVI	View
Temperature	View
Precipitation	View
SurfaceSeaTemperature	View

Disease

CCHF	View
EBOVHVF	View
RVF	View
HANTA	View

CCHF Current Risk Map Ebola Current Risk Map RVF Current Risk Map

Map Satellite Hybrid Terrain

The map displays a satellite view of Africa with a color-coded overlay indicating disease risk levels. A zoom control is visible on the left side of the map.

Search

Environment

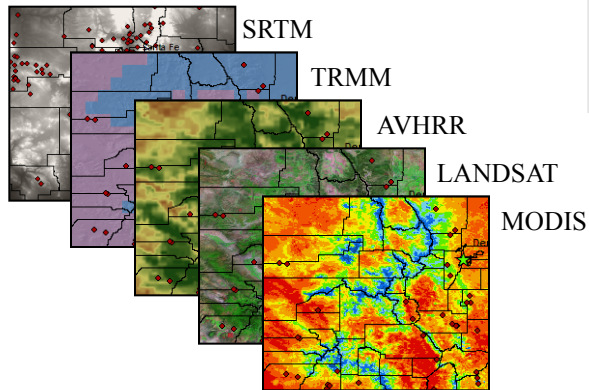
Embedded in Google maps

Other Diseases

(Ebola)



Earth Observations



In situ measurements: vector/animal surveillance & comprehensive list of human cases

INTEGRATED SYSTEM SOLUTION

DATA

ESD & Models

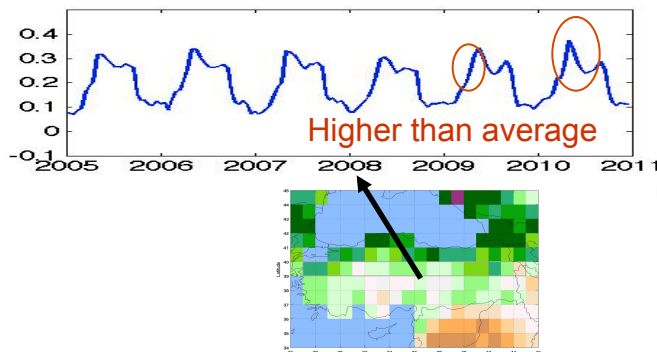


NASA/GSFC vector-borne
eco-climatic modeling

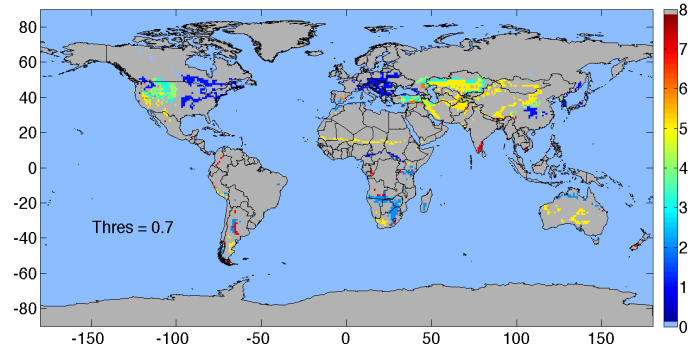
OBSERVATIONS

Decision Support Tools

PREDICTIONS/ FORECASTS



Generalizing

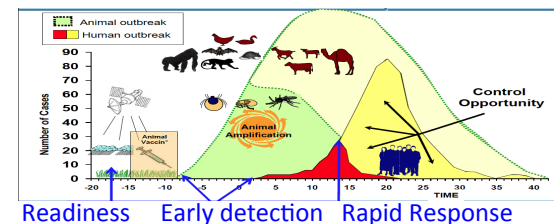


- Temporal/spatial predictive capabilities for monitoring trends in the disease epidemiology/epizootology in a region of interest
- High resolution risk maps for zoonotic surveillance and scientific analysis

- Unique eco-climatic factors or human activities links to increased disease exposure
- Climatic and environmental characterization of risk

Value & Benefits

- Monitoring capabilities for global surveillance and response networking
- Enable timely collections of routine surveillance data
- Enable timely & improved control and prevention efforts
- Better understanding of climate/disease linkage



Improving model – input from partners: Vector Cycles dynamics of vector-borne diseases

During an epidemic, the total number of cases at time $t+1$ due to contacts with cases at time t is estimated as

$$C_{t+1} = S_t(1-(1-P)^{C_t})$$
 Reed-Frost Eq1

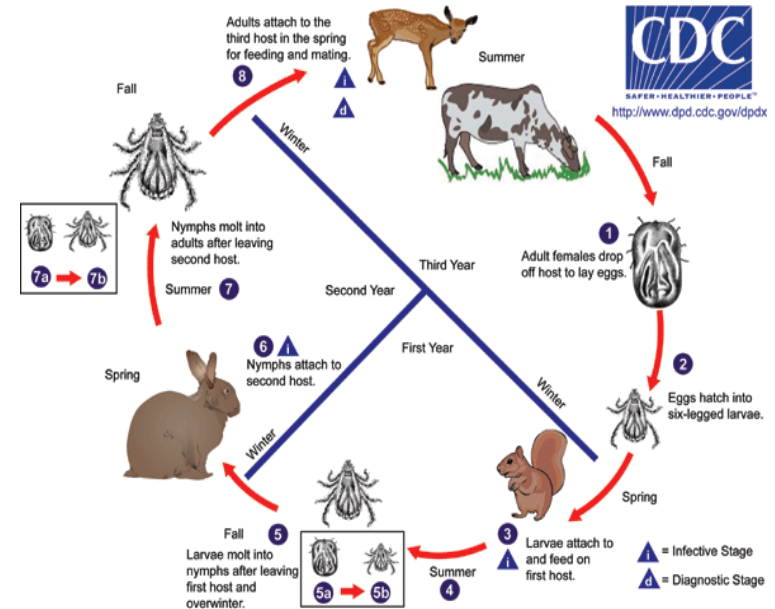
Vectorial capacity (V)

The probability of effective contact is a function of potentially infective bites, $P = V/T$

$$C_{t+1} = S_t(1-(1-V/T)^{C_t})$$

$$\sim S_t(1-e^{-(V/T)C_t})$$
 Reed-Frost Eq2

$$V = (m \times a^2 \times p^n) / (-\ln(p))m$$
 MacDonald Eq



m = [vector density] = function(rain, T_s)
 a = [probability of feeding on a hosts in 1 day]
 = function(G)
 p = [probability of living one day] = function(G)
 n = [length of EIP in days] = function(rain, T_s , G)

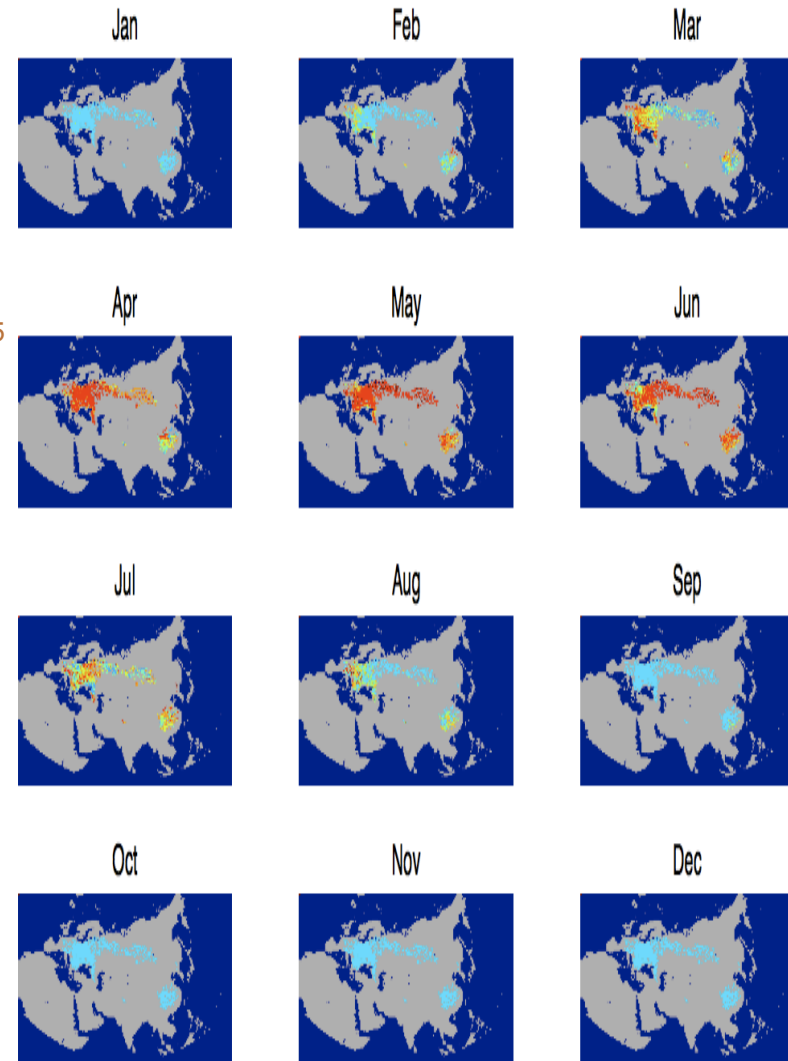
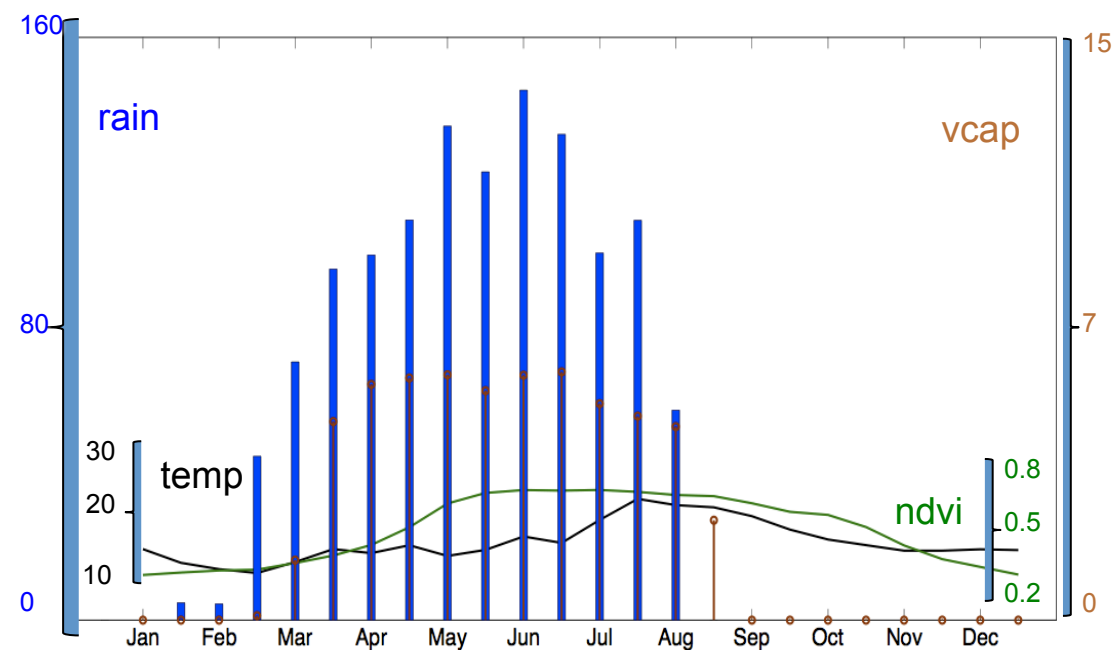


Case study

Hantavirus - vector capacity

Modeling vector capacity dynamics

- Field data from Ukraine
- V as a function of temperature, vegetation index and precipitation

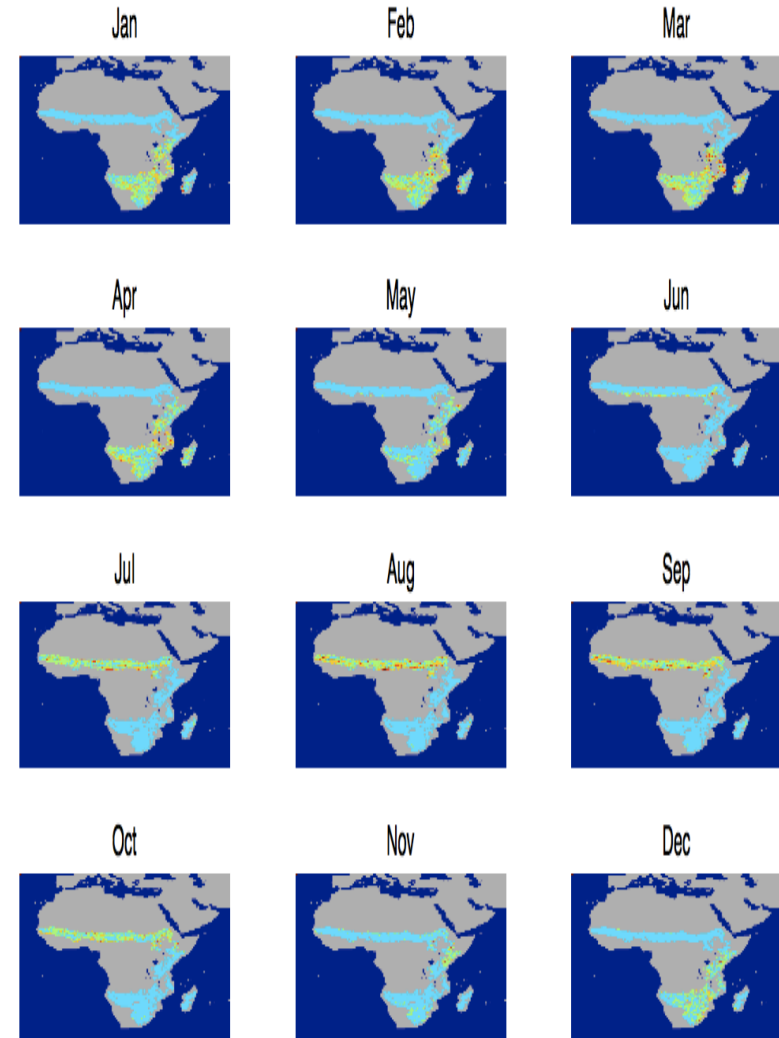
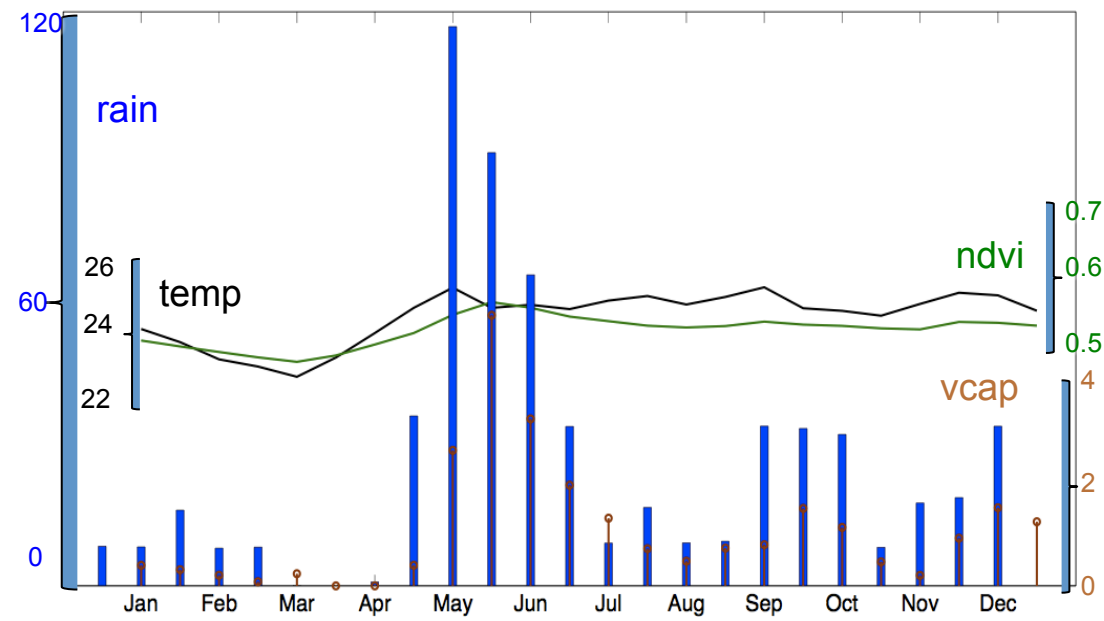


Case study

RVF – vector capacity

Modeling vector capacity dynamics

- Field data from Kenya
- V as a function of precipitation temperature and vegetation index

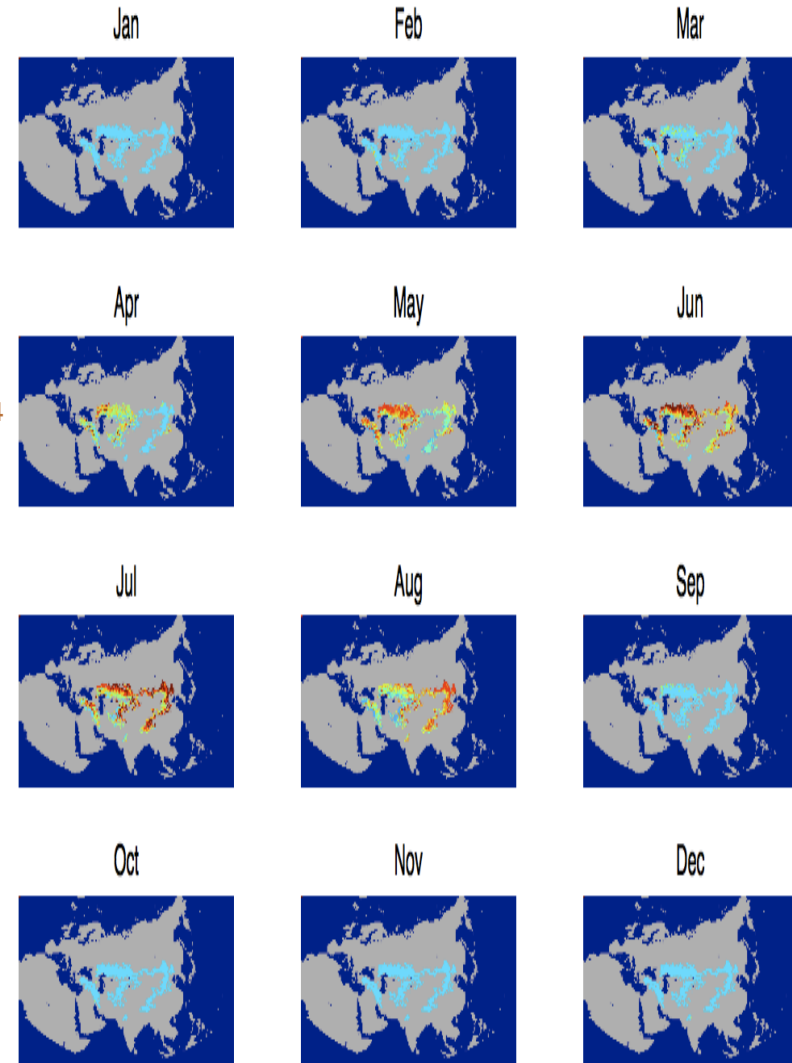
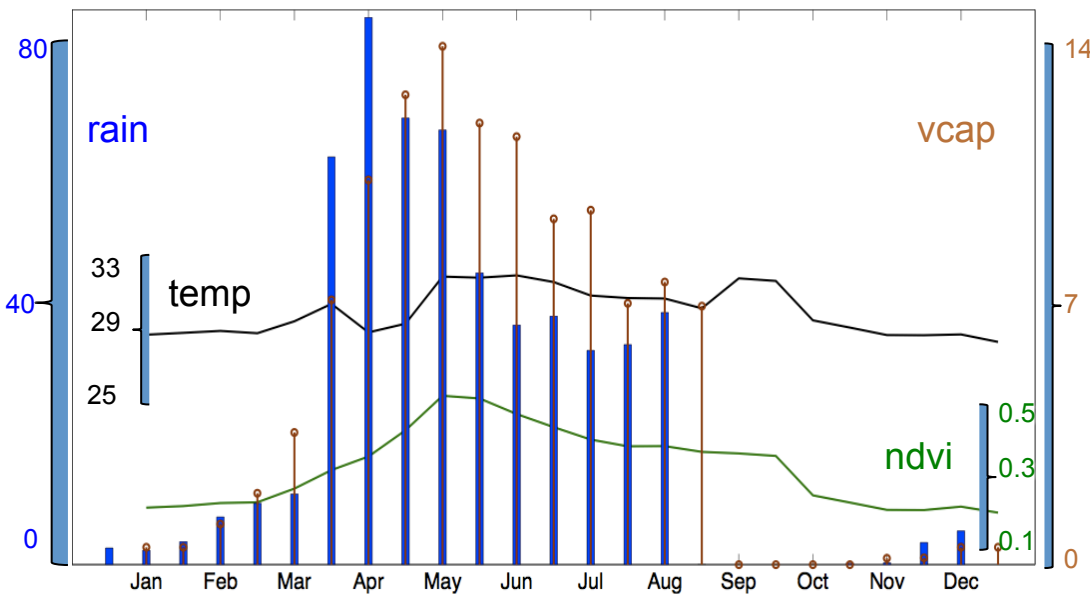


Case study

CCHF - vector capacity

Modeling vector capacity dynamics

- Field data from Turkey
- V as a function of temperature, vegetation index and precipitation

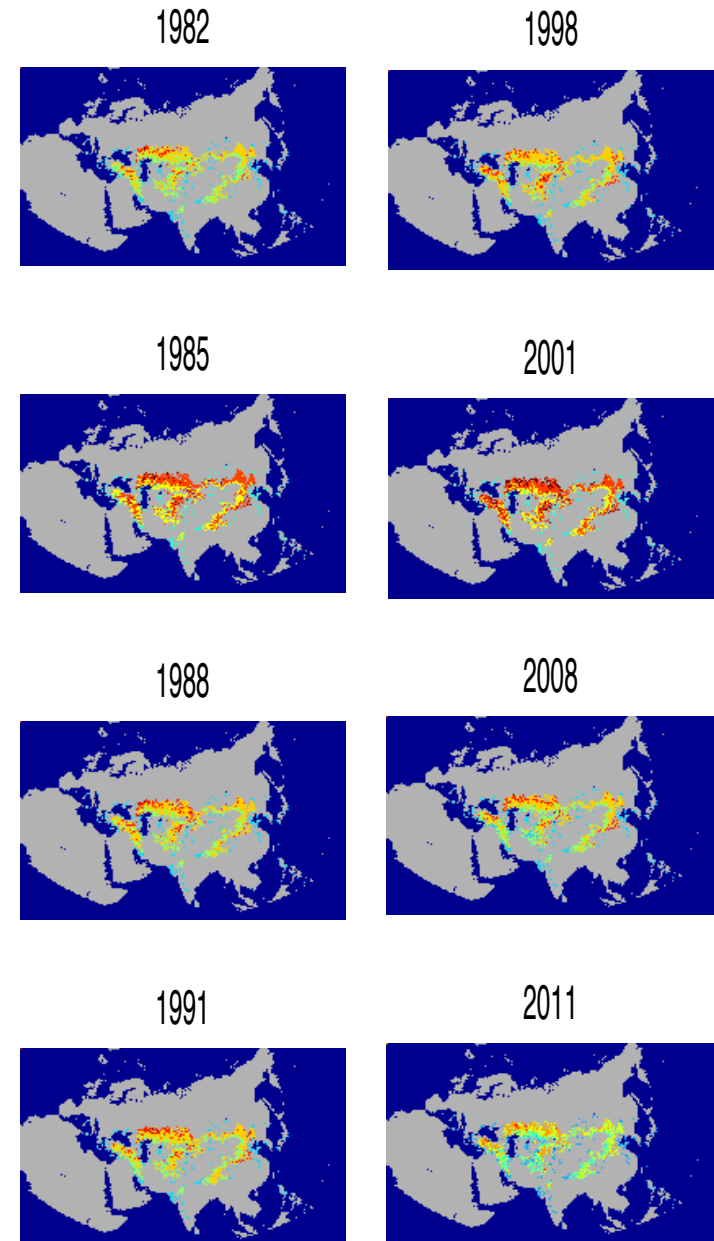
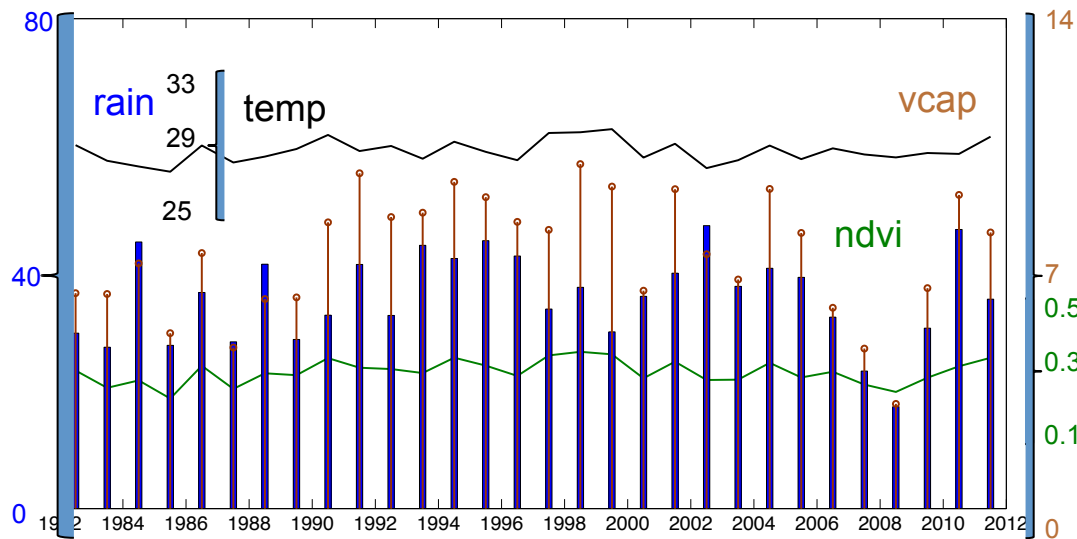


Case study

CCHF - vector capacity
Annual dynamics

Modeling vector capacity dynamics

- Field data from Turkey
- V as a function of temperature, vegetation index and precipitation



Responding to the expansion of AFHSC-GEIS predictive surveillance program

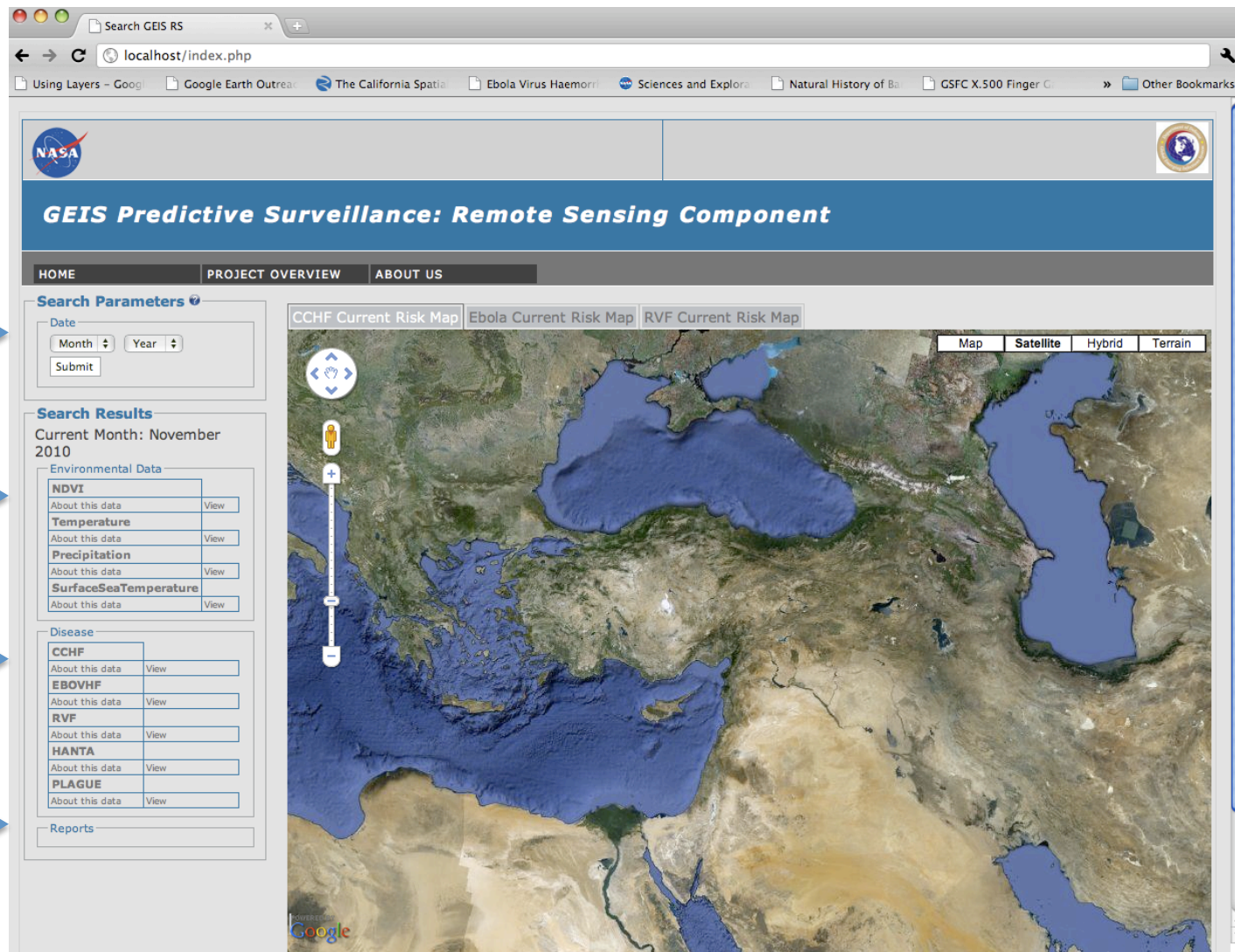
Search

Environment

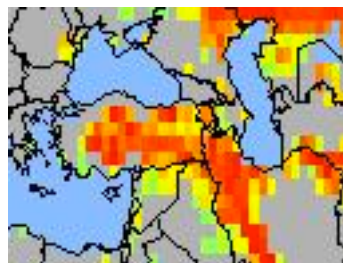
Embedded in Google maps

Other Diseases
(CCHF)

Reports



Integrating prediction from data sharing dialog



CCHF Risk

Search GEIS RS

localhost/index.php

Using Layers - Google | Google Earth Outrea | The California Spatia | Ebola Virus Haemorrhagic Fever | Sciences and Exploration | Natural History of Bacteria | GSFC X.500 Finger Card | Other Bookmarks

NASA

GEIS Predictive Surveillance: Remote Sensing Component

HOME | PROJECT OVERVIEW | ABOUT US

Search Parameters

Date: Month: Year:

Search Results

Current Month: November 2010

Environmental Data

NDVI	<input type="button" value="View"/>
Temperature	<input type="button" value="View"/>
Precipitation	<input type="button" value="View"/>
SurfaceSeaTemperature	<input type="button" value="View"/>

Disease

CCHF	<input type="button" value="View"/>
EBOLA	<input type="button" value="View"/>
RVF	<input type="button" value="View"/>
HANTA	<input type="button" value="View"/>
PLAGUE	<input type="button" value="View"/>

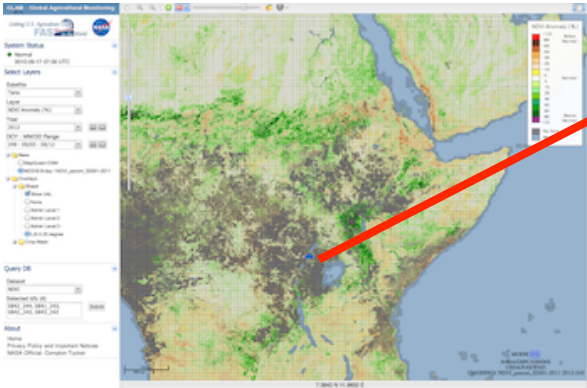
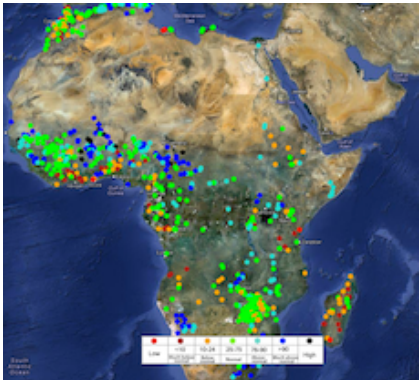
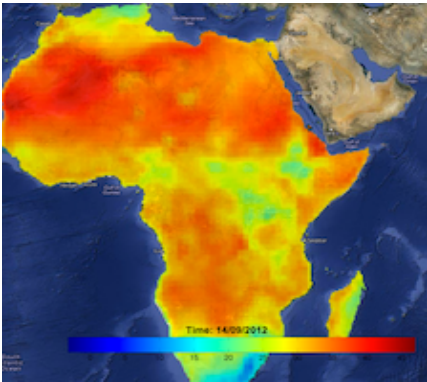
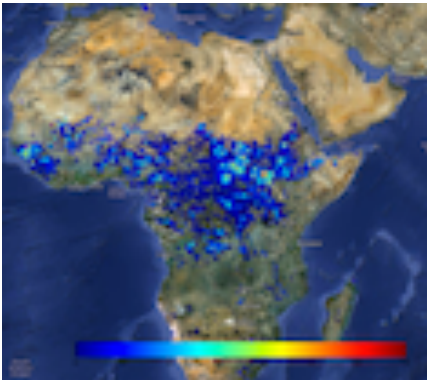
Reports

CCHF Current Risk Map | Ebola Current Risk Map | RVF Current Risk Map

Map | Satellite | Hybrid | Terrain

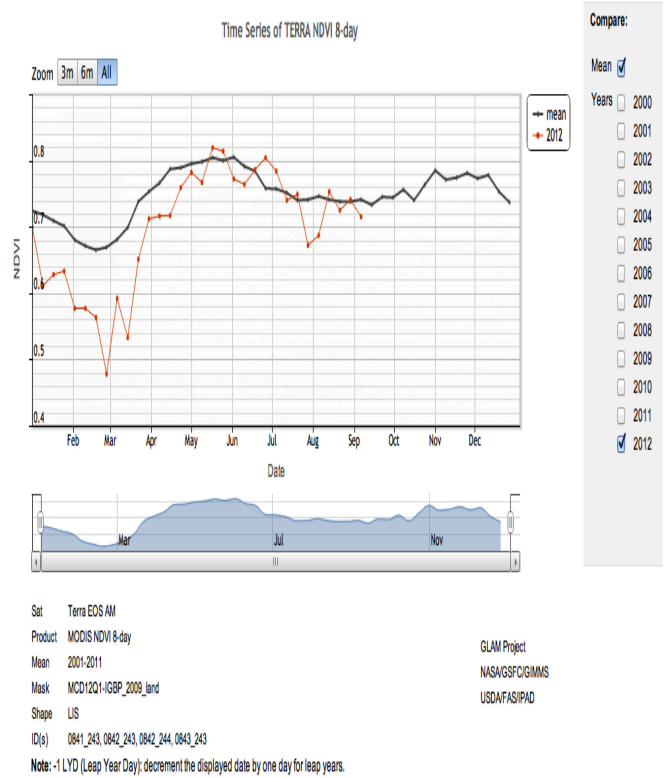


Extension for benchmark measures



Plot 3. Interactive Time Series

[Download Plot 3](#)



About NASA Predictive Surveillance Web RS component

Credits and acknowledgments

Special thanks and acknowledgments go to Clara Witt, Claudia Castaneda, Assaf Anyamba, Ken Linthicum, Emad Mohareb and John Haynes for generously sharing their time, expertise, imagery, and data

THANK YOU!

Jorge.E.Pinzon@nasa.gov